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SIMULATION NEWSLETTER

FRASCA INTERNATIONAL, INC.

From the President

Rudy Frasca

Since our 1949 decision to manufacture aircraft ground training devices, much has been learned about simulation. It's history is as interesting as its technology is changing. We believe the key to safe, efficient flight training lies in cost effective simulation and will present numerous concepts and methods to the reader through this newsletter.

One concept that we would like to stress is transfer of learning. As we see it, simulation is a vehicle to enhance flight training. Too often manufacturers and buyers get involved with the means and not the end, making simulators unnecessarily complex and costly, often to the detriment of its training value. Similar to management by objectives, we believe the adage "form follows function" applies, and dictates simulation designed to meet the requirements of training.

Virtually everyone agrees the airplane is a terrible learning environment, making the quiet, comfortable, climate controlled simulator far more desirable. But all too often these superficial considerations will lead a prospective purchaser to think all simulators are functionally the same, making price the deciding criteria. For instance, table top simulators, adequate for their intended purpose, were originally designed to be used by instrument rated pilots to help maintain proficiency. Unfortunately, their relatively low cost prompted numerous flight schools to purchase them for use in their student pilot flight training programs. We believe they were inadequate for such a job, and many of them may be found gathering dust at various flight schools.

A simulator, or ground trainer, should be designed to do a specific job: cost effective training. Transfer of learning from simulator to aircraft should reduce flying time sufficiently to make the simulator both training, and cost, effective. Our original goals were to achieve 100% transfer of learning; to be able to substitute one hour of simulator for one hour of aircraft time. We have not only met that goal, but now with our computer generated simulation find Frasca simulators actually reduce aircraft time beyond a one for one ratio! So when buying a simulator, don't just look at the fancy hardware; instead, consider its actual training effectiveness.

We hope you will consider saving the *Simulation Newsletter.* The individual newsletters will collectively form the nucleus of a simulation and training manual. It is our intent to share with you the many things we have discovered and developed over the years. Always a stepchild of engineering, we believe there is now sufficient experience and knowledge to consider simulation as its own science.

In future issues, we plan to present more ideas and information regarding the effective use of simulation in flight training. We also encourage readers to submit articles, ideas and comments to help guide the direction of the *Simulation Newsletter.*

CGS: High Potential Simulation

David A. Lombardo

Perhaps the most significant aspect of the Frasca 140/240 computer generated simulation (CGS) series is its virtually limitless expandability. Highly efficient and cost effective, they provide an excellent educational tool in any flight training department, but they are designed for so much more. CGS simulators go beyond the simple "procedures trainer" concept; challenging the user to reach out and develop new uses, to expand into new areas. CGS is the ideal multipurpose simulator for both flight training and research. It is the computer interactive flight simulation (CIFS) software that permits such flexibility.

Currently included with the CIFS option are: playback capability, allowing the instructor to "playback" the student's flight for review and discussion; simulator enroute and approach tracking monitor capability at the instructor's station; and a scoring program. The latter permits up to 16 different, scorable legs. Each leg, as defined by the instructor, scores the student on degree and duration of deviation from established criteria. Scored variables include: pitch, bank, altitude, vertical speed, indicated airspeed, rate of turn, slip and heading.

Currently under development, either by Frasca International, its affiliates or simulator users, are programs for: pilot selection; judgment training; instrument procedures scoring; transponder initiated, automatic task in-

itialization; and perhaps the most exciting, an advanced instructor programming language.

There are essentially two layers of programming language already used with CIFS: the bottom layer language used by the simulator's host computer for routine operations, while the next higher layer interfaces the host computer with the CIFS computer. It is this language that permits the user to develop learning modules and other specialized software. I am of the opinion, as unfortunate as it is, that when it comes to computer assisted instruction, the individual most qualified to develop courseware in any given area is the one least likely to be a computer programmer. In fact, if not always true, it is axiomatic, and certainly one of the prime movers in the development of PLATO and its Tutor language at the University of Illinois. The proposed instructor programming language would be a third layer allowing the instructor to preprogram the simulator, in plain english commands, to perform specific contingency and educational tasks. For instance, to automatically fail the engine inflight if the airspeed falls below Vmc, the following entry might be made:

IF [IAS<VMC]+[ALT>AGL(0)] THEN ENG (L) FAIL

a somewhat devious, but none-the-less effective method of reminding the student that transgressing Vmc isn't a good idea.

With CIFS, the ease of programmability has led a number of institutions to begin development of new software; certainly there is duplication of effort. To help solve this problem, Frasca International is setting up a user's group and newsletter to share ideas, stimulate thinking, and keep everyone informed of new software as it becomes available. The possibilities for development are limitless, such as programmed learning modules on every subject from ab initio maneuvers to advanced pilot judgment training. One area of potential importance to larger flight training operations is the networking of two or more simulators with a single instructor station. Combined with programmed learning modules, a single instructor could monitor several students simultaneously. In such a situation an ATP could be practicing engine out, category II approaches in a simulator next to an ab initio student who is encountering stall training for the first time. CIFS would monitor individual performance, advancing the student through the module, or branching to remedial lessons if there is a problem, always maintaining standardization. If the student consistently falls short of criteria, or has some unforeseeable problem, CIFS would alert the instructor.

In such a system, instructor assumes the role of resource person: solving problems, dealing with unique situations, clarifying and expanding concepts, assuring maximum transfer of training to the aircraft and adding the human touch. The advantages to the student are significant. Instead of a reading assignment for an initial introduction to new task, the student could have an interactive learning experience in the simulator where it is presented on a CRT display, then the simulator automatically "flys" the task to demonstrate it with perhaps a voice synthesizer explaining what's happening. With the optional day/night, full color visual system, the student can relate maneuvers to the outside world as well as the flight instruments. Finally, the student practices the maneuver with CIFS scoring and coaching. Hardcopy results could be recorded and given to the student's flight instructor for preflight discussion during the next scheduled flight period.

Since the direct operating cost of the 140/240 series is so low and the cost of an instructor can be shared by more than one student, it is both a cost effective and high profit system. In fact, initial exposure learning modules might not even require the presence of an instructor, much the same as a reading assignment. The simulator is easily configured to be operable by the student alone. Currently under development is a simulator that would be totally activated by discrete transponder codes so that no instructor is required for operation. The user merely selects the appropriate code, presses IDENT, and the simulator automatically presets itself for the corresponding task. Such a system would be ideal for an experienced pilot who desires to maintain instrument proficiency.

With so much happening, we at Frasca International hope you will take an active part in our users group. Let us know what you are working on and what areas interest you.

Cue and Response

David A. Lombardo

There are three fundamental reasons for the use of simulation: increased training safety, decreased training costs, and high transfer of learning. While few would disagree with these reasons, the question of how to actually achieve a high transfer of learning is often the subject of debate. It is clear that transfer of learning is directly affected by cue and response; however the question is, to what degree must each be present?

According to Rudy Frasca, President of Frasca International, "some simulation engineers feel that both the cue and response must be completely accurate to the aircraft. The aircraft moves, then so must the simulator; the aircraft is flown relative to the horizon, so the simulator must have a visual system. The end product of such reasoning is a simulator that can easily equal, and even exceed, the cost of the aircraft, and is of questionable training value." Other engineers, specializing in human factors, believe that cue and response are both important to transfer of learning, but only response must always be accurate. Frasca feels many cues do not necessarily have to be as accurate as the aircraft, but instead may only relate.

The ab initio training conducted at Frasca's model flight school, Illini Aviation, operates on that fundamental principle. There, instructors rely heavily on simulation in training their students. The Frasca philosophy is to first teach the student in the simulator, to control the airplane precisely by reference to instruments. Once the student is proficient at flying and navigating solely by reference to instruments, then visual flying is a natural by-product of that training. The instructor draws visual parallels to instrument flying: following a road is similar to tracking a VOR; the real horizon is similar to the attitude indicator; and so on. Students taught under this system have been shown to be more proficient at an earlier stage of training than students taught under more conventional methods. In fact, these students meet private pilot proficiency and are able to fly under instrument conditions and conduct a VOR letdown with a high degree of ability in the same time it takes other students to reach basic FAA private pilot proficiency!

Another ongoing, informal transfer of learning study, conducted by Frasca Aviation, is taking place in a helicopter hover simulator without a visual system. The simulator is composed of a realistic helicopter cockpit and a model. The model, a miniature helicopter, is visible from within the cockpit and has six degrees of motion. The cue provided by the model, while not the same as being inside a real helicopter, is highly related. The response is accurate, with the student observing the model as it responds to control inputs.

The ab initio training program utilizes one hour in the hover simulator before the student flies the helicopter. Initially the student is briefed on the relationship between the collective and the cyclic, and how they interact with the model helicopter. After a few minutes of discussion, the student is left alone in the simulator for 30 minutes of solo practice. The instructor then returns, checks the student's progress, answers questions and gives the student some precision hover exercises to practice for an additional 20 minutes of solo. At the end of that time, the instructor again returns, checks student progress, answers questions and sends the student to the helicopter flight instructor.

The findings of Frasca's study have been nothing short of amazing. After one hour in the hover simulator and 15 minutes of dual instruction in the helicopter, students who had never been in a helicopter before are averaging a 5 hour proficiency level. Students without simulator time average 5 hours of dual instruction to reach hover proficiency. Students with simulator time not only achieved hover proficiency, but are reaching solo proficiency in five hours!

There are undoubtedly many complex reasons for such a high rate of learning transfer. Clearly the environment within a helicopter is less than conducive to learning, so the low threat environment of the simulator facilitates a positive learning situation. Also significant is the power of self discovery, with the student actually learning how to hover through trial and error, but in a situation which greatly reduces the margin for failure. Here, the strength lies in the immediate and accurate response of the model, giving continuous feedback to the student.

Finally, the student is afforded the rare opportunity of actually being able to fly without interruption. According to Frasca, "in the helicopter, the flight instructor must constantly override the controls, seldom, if ever releasing them completely during the early stages of training. This is due to the criticality involved in hover training, which by nature must be done close to the ground where there is little margin for error. The negative consequence is it often takes an hour or more before the student is able to determine who is controlling the helicopter at any given moment." This restricts the student from developing a feel for appropriate control movements and pressures, and significantly increases the time required to reach hover proficiency.

Frasca Citation II built for Pemex.

Simulation & General Aviation Flight Training

David A. Lombardo

As simulation becomes more cost effective for general aviation than ever before, it is worth reviewing its benefits. Under FAR Part 61: Certification of Airmen, the regulation that covers non-FAA approved flight training, simulator time still may not be credited toward the Private Pilot Certificate. However, for the Commercial Pilot Certificate, 250 hours of flight time are required, but 50 hours may be simulator instruction from an authorized instructor.

The recent change in the instrument rating requirements lowering the applicant's minimum total time to only 125 hours hasn't changed the simulator allowance: 20 of the required forty hours of instrument flight time may be in an approved ground trainer. It is important to note that of the 40 hours of instrument flight experience required, only 15 must actually be instrument flight instruction by an authorized instructor, and ten of those hours may be in an approved ground trainer! That means a 105 hour private pilot can get 20 hours of simulator instruction with an instrument ground instructor, 15 hours of airplane hood time with a current safety pilot, and only 5 hours instrument instruction in an airplane by an authorized flight instructor! Instrument currency, required every 6 months, allows 3 of 6 hours and all 6 approaches to be flown in a simulator without an instructor. For the Airline Transport Pilot Certificate, which requires no dual instruction, 25 of the required 75 hours of actual or simulated instrument time may be in a simulator.

Under FAR Part 141, the regulation governing FAA approved flight schools, generally a greater percentage of simulator time is allowed. The school must receive specific approval of the training syllabus for each course, including the type of simulator and the manner in which it will be used. The school has considerable flexibility in the initial design of the syllabus, and in general the FAA has been amiable toward approving a wide variety of syllabi. Past approvals have included the following simulator credit: 5 hours of the 35 hours for the Private Pilot Certificate; 20 of the 190 hours of flight time for the Commercial Certificate; and 20 of the 35 hours of instrument instruction for the Instrument Rating. It is important to note that these are minimum times. In the case of the Private Pilot, estimated time to solo ranges from 12 to 20 hours with an average time to certification being 50 hours. Typically this is marginal, however extensive use of simulation in the presolo stage significantly increases learning in the aircraft.

In an 18 month study released by Purdue University in 1967, researchers found 38 hours of aircraft time and 10 hours of Frasca ground trainer brought the students up to FAA Private Pilot certification standards. In what was the first Private Pilot training syllabus designed for use with modern trainers, Purdue stressed extensive exposure to instrument training first, using the "transfer of training" concept. Their study proved that the transfer approach maximizes the amount of ground trainer learning which can be transferred directly to inflight situations. Variables considered by the Purdue staff included instrument panel layout; aircraft and trainer parameters; FAA requirements; and special training requirements for colleges and commercial flight schools.

That study was followed by a second one, using the same subjects. After Private Pilot certification the subjects proceeded directly to preparation for the Instrument Rating. Building on the early instrument exposure during their Private Pilot training, the instrument course also maximized the transfer of training concept. No more than 101 hours of total time was necessary for the students to qualify for instrument ratings!

Numerous colleges such as Purdue, the University of Illinois, the University of North Dakota and Gateway Technical Institute in Kenosha, WI are presently integrating ground trainers into their flight training programs with great success. However, Rudy Frasca, President of Frasca International feels sophisticated ground trainers could be used for an even greater proportion of training. It was for that reason he purchased an airport in Urbana, IL. Frasca Field is dedicated to being a model flight training school.

By efficiently integrating the use of ground trainers into the training syllabus, he hopes to have student pilots well prepared for real world, instrument operations with 75 hours of aircraft and 3550 hours of ground trainer. The approach has been gradual, consistent with the FARs. "We feel that proper ground trainers could eventually be used for up to 50% of training hours," Frasca said. There is immediate emphasis on controlling the aircraft solely by reference to instruments. The new student begins with two hours of instruments in the trainer then an hour of hood time in the aircraft. Another hour of trainer time, then into the aircraft for a transition to contact flying. Frasca stressed, "this is a critical period and care must be taken in assuring substitution of outside cues for instrument indications."

He feels there are three main reasons that make this approach valid. First impressions are lasting impressions. If a student learns instrument flying initially, it will become second nature. Secondly, he believes if a person learns to fly on instruments, contact flying comes free. If a person learns contact flying first, instrument flying is a new ant strange experience requiring greater time and expense. Finally, much contact training now done, is better suited to instrument flying in a ground trainer, usually giving a 2 to 1 trade off. As an example, the same tracking technique used to fly a road, is used to fly a VOR. Another example is the technique used to transition from climb to cruise. This would involve closing the cowl flaps prior to leveling off, reducing the manifold pressure then RPM after the airspeed has picked up, roughly adjusting the elevator trim, adjusting the manifold pressure due to the effect of reduced RPM, readjustment of trim, then setting the mixture control for the required EGT setting. Such a task is better learned in a ground trainer and would have a high transfer rate to either instrument or contact flying in the aircraft.

Utilizing this method a student is able to fly a complex instrument pattern prior to initial solo; a VOR instrument letdown prior to Private certification. Continuing with a well organized syllabus would qualify the student for an instrument rating in 110 hours. Frasca feels that a total commercial/instrument/multiengine training package, starting from the novice, could be accomplished in a total of 150 hours of proper, concentrated training; fifty of those hours would be ground trainer time.

Simulator credit under FAR Part 135 (for commuter airlines) requires the operator to submit a training syllabus to the FAA for approval. The syllabus must include the type of aircraft and simulator to be used, and the maneuvers and approaches the operator wishes to receive credit for in the simulator. We expect Part 135 commuter programs utilizing ground trainers to continue to be individualized depending on aircraft and type of flying involved. The amount of credit for the ground training involved would depend on its sophistication in meeting the commuters' needs.

Frasca feels visual systems will play a larger role in general aviation simulation. "However, we question their cost effectiveness since the student must use the aircraft visually for his training. Except for teaching approaches to the runway, what value would a visual system have?" Frasca asked. "We do offer such systems since they are often desired by the customer. Motion, on the other hand, will become a thing of the past in general aviation trainers. Evidence appears to be against it. Very simply, without 'g' forces, the motion cues are not real and obviously should not be used as a basis for instrument flights."

Due to the high cost of fuel and aircraft operation and the complexity of the man-machine relationship, general aviation needs another answer than our traditional flight training approach. It needs greater recognition for simulation.

Up to date . . .

The Chicago-based **Aviation Training Enterprises (ATE)** holds the record of having more Frasca simulators than any other corporation. In the past 12 months they have acquired 8 additional trainers, bringing the total they have purchased to 55. Making maximum use of simulation has lead ATE to become one of the most successful instrument flight schools in the world.

Another strong Frasca supporter is the prestigious **University of North Dakota** (Grand Forks, ND) whose Center for Aerospace Studies has recently acquired its 12th Frasca simulator. The school's simulation capability includes: 4 new 141 computer generated single engine trainers (one with visual), a 142 multiengine trainer, a twin engine turboprop and a Bell 206 helicopter trainer. Their program, rapidly becoming internationally renown, is so impressive that *Kai Boiardt* and *Lars-Uno Olsson* made a special trip to North Dakota just to become familiar with the Center's programs. Kai and Lars were conducting acceptance tests at the Frasca factory in Champaign, Illinois for Sweden's **Foersvarets Materielverk's** new Frasca Bulldog flight simulator.

John Rembish, Assistant Manager of the **Edmonton Flying Club,** (Edmonton, Alberta, Canada) tells us that the club's 101G is still in tip top shape with over 15,000 hours! The club recently acquired a playmate for the 101G, a brand new Frasca 242 two place, multiengine trainer.

Meanwhile, at **Mount Royal College** (Calgary, Alberta, Canada), a contest is underway unknown to the contestants. Their Frasca 101G also has over 15,000 hours - watch out Edmonton Flying Club, the race is on. *Neil Sissons* of the Aviation Department is enjoying the addition of a new Frasca 141 to compliment the 101G.

CSE Aviation Limited's **Oxford Air Training School** (Oxford, England) has recently acquired two more Frasca trainers under the watchful eye of *Peter Terry,* Head of Simulated Flight. Peter now has over 10 Frasca trainers in service; one with more than 16,000 hours! The largest civil flying school in Europe and the fastest growing engineer training school, OATS has a teaching staff of over 100 and more than 50 training aircraft. They offer complete flight training in single engine, multiengine and helicopters as well as maintenance engineer training for many of the world's leading airlines and governments.

Recently Frasca International was host to *I.Y. Sani* and *G.O. Aba* from the **Nigerian Civil Aviation Training Centre.** For almost three weeks they underwent Frasca's comprehensive maintenance training program, learning how to keep two new 141 single engine trainers working at peak performance, and took in the sights which included an airport open house at Frasca Field complete with a War Birds airshow.

Bill Hemphill of **Northeast Louisiana University** (Monroe, LA) is flying through cloud nine these days. Not only has the aviation department moved into a brand new building, but it has also purchased new 141 single engine and 142 multiengine trainers with flight directors and visual systems! NLU can certainly be proud of its leadership in Louisiana university aviation.

Speaking of leadership in university aviation, **Purdue University** (Lafayette, IN) has purchased its 7th and 8th Frasca trainer since 1966. The two new 141s will be replacing Frasca 103s. Good luck and thanks to *Tom Howard!*

Inquiries about Frasca International's new Museum Aircraft Demonstrator are increasing. The "hands on" demonstrator allows museum visitors to "fly" a miniature airplane, learning the relationship between aircraft controls, control surfaces and the three axis. The first demonstrator was designed and built for the **Franklin Museum** (Philadelphia, PA). Shortly thereafter one was acquired by the **EAA Museum** (Oshkosh, WI) and has been enjoyed by thousands of visitors. The **St. Louis Science Center,** (St. Louis, MO) added one to their permanent collection this past August, and most recently the **Milwaukee Public Museum** (Milwaukee, WI)

Frasca Bulldog Simulator built for Swedish Air Force.

has also added one to their collection.

Other recent acquisitions include: **Brazos Aircraft** (Brazos, TX) a 100G single engine trainer; **Armada Nacional de Colombia** (Colombia, South America) a 121 single engine trainer; **Petroleos Mexicanos** (Mexico), a 122 multiengine trainer; and **Olympic Aviation** (Greece), a 210T multiengine turboprop simulator.

Tab Books has recently released a new book by *Paul Garrison* which gives an in-depth coverage of general aviation simulation. **Flying Without Wings: A Flight Simulation Manual** details current FAA guidelines on simulator time credit towards licenses, ratings, and currency; discusses teaching methods for simulator instructors; and provides the reader with insights into different types of simulators available. At $14.95, the book is available through Illini Aviation's Pilot Supply Shop, postage paid. Orders may be placed by sending a check to Illini Aviation, Inc.; 1402 E. Illini Airport Road; Urbana, IL 61801. For VISA and MasterCard orders, call (217) 367-8441.

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Frasca 142 light twin engine trainer built for Northeast Louisiana University.

Frasca general purpose turboprop trainer as used by University of North Dakota.

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